AUTOMATED BLOOD AND LUNG COLLECTING AND HANDLING SYSTEMS FOR POULTRY-PROCESSING PLANTS

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ABSTRACT

Two automated systems were designed, developed, and commercially tested to accumulate blood in troughs and basins and to transport the blood (system A) and the blood and lungs (system B) through pneumatic tubes. System A picks up blood at predetermined intervals, deposits it in a holding tank, and eventually moves it into a transport truck to be hauled to a rendering plant. System B also accumulates blood and picks it up at frequent intervals. In addition, it picks up accumulated lungs, mixes them with the blood, and feeds this material into an onsite continuous rendering operation. Both systems are highly effective and reliable in handling the product and greatly reduce the pollution entering the plant effluent. After the installation of system B, total effluent pollution was reduced in a poultry processing and rendering plant by: BOD_5 (biochemical oxygen demand), 44%; fat, 26%; and suspended solids, 24%. **KEYWORDS: pneumatic waste disposal, poultry, poultry-blood collection, poultry-plant engineering, poultry processing, waste, waste disposal, water-pollution control.**

INTRODUCTION

Background

Antipollution legislation passed in recent years by city, State, and Federal agencies has created problems for poultry processors in the handling and the disposal of waste products. Blood, feathers, heads, feet, viscera, and other inedible parts comprise about one-fourth of the live weight of the poultry processed. Problems arise primarily from the traditional methods of transporting these waste products out of the plant in a stream of water to a collection station (offal room). There, most of the solid materials are screened out of the water and either loaded onto trucks for shipment to a rendering plant or conveyed directly into onsite rendering facilities. After being screened, the effluent remains heavily loaded with dissolved and suspended organic matter.[1] Two of the most troublesome pollutants are blood and fats.[2]

Blood has been reported to have a BOD_5 (biochemical oxygen demand) potential of over 92,000 mg/l.[3] Current methods of collection allow a high percentage of BOD_5 to enter the plant effluent. Broiler-class chickens are reported to contain about 7.5% of their body weight in blood, 45% of which is collectable during the slaughter operation,[4] amounting to about 0.125 lb per chicken

[1]Pearson, G. A., Knibbe, W. G. J., and Worley, H. L. 1972. Composition and variation of waste water from food processing plants. U.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS 41-186, 10 pp.

[2]Singh, S. P., Wesley, R. L., and Budd, E. A. 1973. Characteristics of poultry processing effluent. Poult. Sci. 52: 1472-1481.

[3]Porges, R. 1950. Wastes from poultry dressing establishments. Sewage Ind. Wastes 22: 531-535.

[4]Kotula, A. W., and Helbacka, Norman V. 1966. Blood volume of live chickens and influence of slaughter technique on blood loss. Poult. Sci. 45: 684-688.

or about 14 gal per 1,000 birds. A small amount of the blood that is not collectable continues to drain from the carcasses as they pass through the succeeding processing operations, consequently ending up in the effluent. The collection and containment of the blood released in the slaughter area, however, can result in a significant reduction of effluent pollution. One report states that the BOD_5 waste load at this point could be reduced by 38%,[5] and another study indicates a possible reduction of 14 lb of BOD_5 per 1,000 chickens processed.[6]

The objective of this research project was to develop automated waste-handling systems for containing and collecting blood during slaughter operations to reduce the pollution from commercial poultry-processing plants. This is a report on the design, development, and commercial testing of the first components of the overall automated waste-handling systems for handling all waste from poultry-processing operations.

Current Methods

At present, there is no standard method for handling blood in commercial poultry-processing plants. The birds, suspended by the feet on an overhead monorail conveyor, pass through the slaughter operation (generally stunning and killing) and continue into an area often called the "blood tunnel" (fig. 1), usually a narrow room with glazed tile walls and a smooth troweled concrete floor to facilitate cleaning. The birds bleed out while passing through this area prior to entering the scald tank, and the blood falls to the floor and is allowed to accumulate until breaktime or until the end of a work shift. Consequently, much of the blood, especially the serum that separates from the clotted mass, ends up in the plant effluent. The blood accumulates several inches deep on the floor, some splattering on the walls during the terminal struggle of the chickens. Besides the pollution it causes, such bleeding creates a messy situation for cleanup workers.

Until tighter antipollution ordinances compelled them to do otherwise, some plants simply flushed the accumulated blood down the drain into the effluent. In smaller plants the blood was scooped into barrels and carted out by hand. In other plants diaphragm pumps or vacuum systems with manually operated pickup hoses were utilized: the vacuum pump used for lung removal was employed for cleanup during break periods or after plant shutdown. These systems are at best only semiautomated and do not operate efficiently. Because most of these systems allow blood to accumulate on the floor, workers must wade into the area to scoop up the blood and push it into a sump, or vacuum it up with a flexible hose. The job is unpleasant and hazardous because the blood makes the floor slippery. The blood remaining on the floor and walls is hosed down into the drains during plant cleanup, creating a pollution problem. Also, if the opportunity exists, the temptation is always present for cleanup personnel to take the short cut of flushing all the blood into the drain.

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FIGURE 1.—Typical "blood tunnel" where slaughtered birds bleed out and blood collects on the floor.

Blood is normally mixed with feathers for processing at the rendering plant because of the high protein content of both byproducts, but it may also be rendered with the offal. The most common practice is to combine at the processing

[5]Federal Water Pollution Control Administration. 1967. Poultry processing profile. The cost of clean water, Vol. III. Industrial waste profile No. 8—Meat products, 28 pp.

[6]Porges, R., and Strugeski, E. J., Jr. 1962. Wastes from the poultry processing industry. 14 pp. Tech. Rep. W62-3. The Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

plant the products that are to be rendered together. Offal trucks have a separate compartment for hauling these byproduct mixes. In some instances, blood is transported in separate tanks to insure that none of it drains into the plant effluent, as is sometime the case when blood is loaded on top of the feathers or offal as it accumulates.

EXPERIMENTAL SYSTEMS

Two experimental negative-pressure (vacuum) systems were designed, constructed, and commercially tested in poultry-processing plants for removing from the slaughter area (1) collectable blood (system A) and (2) blood and lungs (system B). In addition to being designed to minimize plant effluent pollution, reduce labor for plant cleanup, and establish a better working environment, the systems were automated to overcome human elements of negligence, forgetfulness, and incompetence. Flexible enough for determining design criteria for processing plants of various production levels and requirements, the systems were tested and modified until found to be reliable and effective.

The systems were designed (1) to collect the blood and contain it in the slaughter area (to prevent messiness and facilitate pickup), (2) to pick up and transfer the blood (and lungs) to a collection tank at predetermined intervals, and (3) to discharge the material from the collection tank. The systems were intentionally overdesigned to function in situations that might be found in any processing plant, and they are much more complex than most plants would require.

Blood System A

Components

The basic hardware needed for system A includes (1) two catch basins for accumulating the blood in the slaughter area, (2) a 500-gal collection and storage tank, (3) a 400-ft^3/min vacuum pump (rated at 24 inHg vacuum) with a 30-hp electric motor, (4) and the necessary pipe, valves, and fittings (fig. 2). Except for certain features of the collection tank, all of these components are standard parts, or of simple design. The controls for the system were designed to automate completely the pickup and discharge of blood.

For the collection and storage tank, a 500-gal tank with bell-shaped ends and ¼-in steel walls (a propane gas tank) was modified to provide

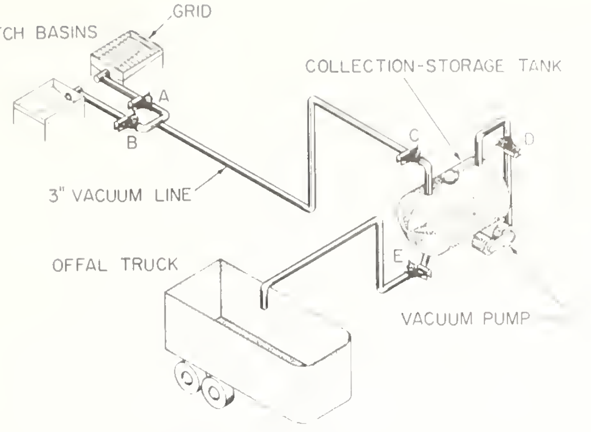

FIGURE 2.—Schematic of an automated blood-collection system (system A).

ports for air evacuation, material entrance and exit, visual inspection, gages, probes, and other devices (fig. 3). The tank interior was coated with a rust preventive and an acid-resistant paint. A baffle was installed inside the tank to prevent material from being pulled into the pump, with an electrical probe (modified milk-tank probe) extending 4 in below the baffle. When the liquid reaches the probe electrodes, the pickup cycle is stopped to prevent overfilling the tank. A 12-in-diameter inspection port was installed for access to the tank interior for visual inspection and for equipment installation and repair. Also installed was a clean-in-place (CIP) assembly consisting of two parallel ¾-in pipes mounted about 1 ft apart in the top of the tank and two ball-type spray heads, one at each end of the tank. One-sixteenth-inch o.d. holes were drilled 2 in apart in the sides of the pipes and arranged to rinse the tank interior, and the assembly was connected to cold-water lines.

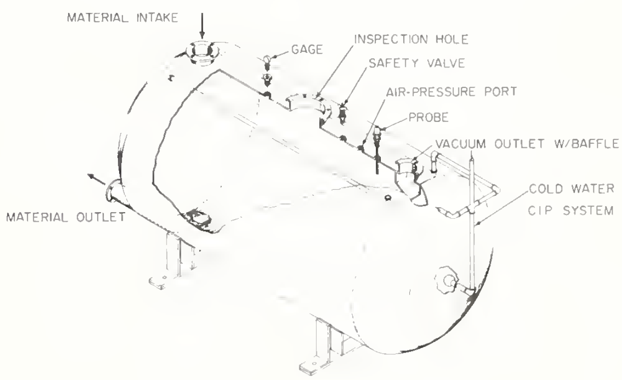

FIGURE 3.—Cutaway view of the experimental collection and storage tank for system A.

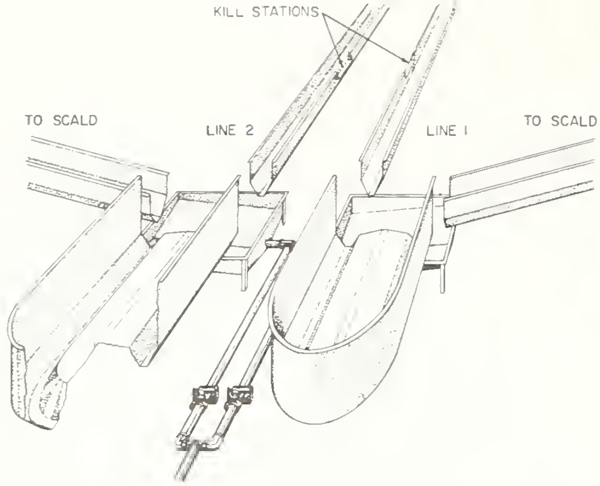

FIGURE 4.—Illustrated view of collection troughs and basins for system A.

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FIGURE 5.—Blood-collection assemblies for system A with pipes connected to basins. Personnel shown are backing up automatic killing machines.

The prototype blood-collection system was installed in a processing plant that had two defeathering lines with a total capacity of 9,600 birds per hour, generating approximately 135 gal/h of collectable blood (figs. 4 and 5). The catch basins (fig. 2), one under each line, were designed to hold about 80 gal each. The 3-in vacuum line was equipped with a **T** fitting to connect to both catch basins, and a quick-opening valve was installed in each branch line (fig. 2, A and B) for independent switching to either basin.

Operation

The volume of blood generated is too small for continuous pickup to be efficient, and so it is automatically collected at predetermined intervals throughout the day. Two timer clocks control the sequence of events: the first initiates the blood-pickup cycle ever hour and the discharge cycle every 2 hours, and the second triggers all intermediate events during discharge from the storage tank on a single 4-min cycle.

At the end of 1 hour of operation, the system is energized to initiate the pickup cycle, placing a vacuum on the collection and storage tank. During the pickup cycle, valve E on the collection and storage tank is closed and valves C and D open (fig. 2). Valve A on the first catch basin opens, and the accumulated blood is drawn from it into the collection and storage tank. Valve A closes, and valve B opens, and the blood in the second catch basin is drawn into the collection and storage tank. The system shuts down for an hour, repeats the pickup cycle, and then enters the discharge cycle.

During the discharge cycle, valves C and D to the collection and storage tank are closed and air pressure (15 lb/in^2) is applied to the tank. At discharge, valve E opens, and the blood discharges into the receiver truck in 45 seconds. To insure that the receiver truck is in place, a warning whistle blows and a red light flashes in the offal room 75 seconds prior to discharge. A switch is located in the offal room to stop the cycle if necessary. Just before discharge is completed, the CIP system is activated by the timer, spraying the tank interior with cold water that mixes with and is discharged with the final portion of blood. The cleaning of the tank completes one overall 2-hour cycle, and the system shuts down.

Blood and Lung System B

System B (fig. 6) differs from system A in four significant ways: (1) two defeathering lines (12,000 birds/h) pass over one catch basin (fig. 7); (2) in addition to blood pickup, the system also receives lungs from the lung-collection system; (3) blood and lungs are picked up at 7.5-min intervals; and (4) the system dispenses blood and lungs from the receiver tank into a surge tank at an onsite continuous rendering operation.

The processing plant at which system B was installed has four eviscerating lines with automatic lung-removal machines on each line. The lung system has its own vacuum pumps because an uninterrupted vacuum is vital to proper lung removal and continuous plant operation. Two lung-collection tanks are provided to make pickup without interrupting continuous lung removal in the eviscerating room (fig. 6). Normally valve A between the tanks is open, and valves B and C on the bottom tank are closed. Lungs collected

in the top tank drain into and accumulate in the lower tank. When the pickup cycle begins, valves E, F, and H to the lung and blood receiver are closed, and a vacuum is applied to the tank. The valve to the blood collection basin (D) opens, and blood is drawn from the basin into the receiver. Valve D closes and lung pickup begins. Valve A between the collection tanks closes to begin the pickup cycle. Valve B opens to release the vacuum on the lower tank, and valve C opens to allow lungs to be pulled into the blood and lung receiver. At the end of the cycle, valves B and C are closed, and valve A opens again for the normal lung-collection operation.

The lung and blood receiver, a cyclone type with about a 500-gal capacity, was mounted above the surge tank and located in the rendering plant adjacent to the processing plant. A vacuum was supplied by a pump with a rated capacity of 375 ft^3/min at 18 inHg. Collected blood and lungs drained into the surge tank when valve F was opened (fig. 6). Valve G was manually operated and adjusted to allow the product to drain slowly into the surge tank to avoid sudden overloading. Cleanup water was diverted into the sewer rather than into the cookers by closing valve F and opening valve H.

DISCUSSION

System A has been working satisfactorily in a commercial broiler-processing plant for 2 years, and system B for 1 year. Many changes have been made to improve their performance and reliability.

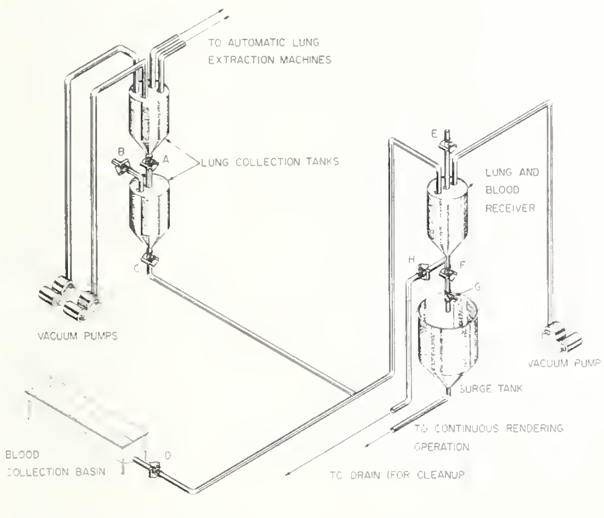

FIGURE 6.—Perspective view of combined blood and lung handling system B.

Operation of the systems has provided data for a number of designs for processing plants with varied requirements. Although all variables could not be investigated, the experience gained was enough to establish essential information.

Drain troughs and a basin must be provided to collect and contain the blood in the slaughter area to prevent it from getting into the plant effluent and to facilitate pickup. For each processing plant these must be custom-designed to fit underneath the slaughter line and to allow the chickens to hang below the sides (figs. 4 and 5). If an electric stunner is used to minimize terminal struggle, little blood will splatter on the walls and floors.

As much slope as possible should be built into the troughs and into the bottom of the collection basin for drainage of the blood into a centrally located sump. Experience has shown that fresh blood will not run freely down surfaces of any angle; it coagulates and the separated serum lubricates the surface. On such surfaces, vibrations will cause the clotted blood to slide down but only in a sporadic fashion. The depth of the blood influenced separation of the serum from the clot, and a **V**-shaped bottom in the drain trough appeared to work better than a flat bottom.

Two methods were tested for evacuating blood from the collection-basin sump. One provided for the permanent attachment of a pipe to the exterior side or bottom of the sump, the second for a vertical pipe descending into the collection sump from above. When using the first method (fig. 2), the vacuum line must be connected to the bottom of the sump. The 3-in pipe appeared to be the smallest practical size to prevent clogging. Wing feathers in the blood can bridge across a smaller pipe and stop up the system. However, even with the 3-in pipe the possibility of line

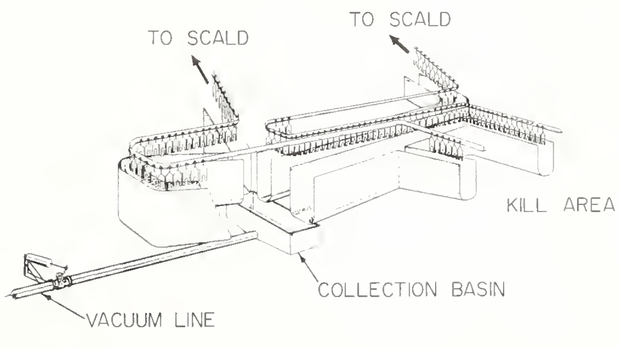

FIGURE 7.—Collection troughs and basin in slaughter area of system B.

stoppage exists because whole birds (small birds) can enter the line, jamming valves and elbows. A grid should be placed over the collection basin to screen out such large objects (fig. 2), but if the grid openings are too narrow the clotted blood may bridge them, especially when mixed with feathers. Grid openings of 2.75 in seemed to be satisfactory.

The second method of evacuating the blood collection basin, by vertical tube (fig. 8), has some advantages over the first. Not fixed to the sump, the pipe is less of an obstacle, since it is not routed along the floor, obstructing aisles and walkways. The clearance of the pipe end in the sump, about 1.25 in, does not permit a whole chicken to be pulled into the system. Fewer turns in the pipe will be required, and the line can be routed across the roof and straight down into the blood-collection basin.

For the system to pick blood up to heights greater than 12 to 15 feet, air must be fed into the line 3 to 4 feet above the pickup end (fig. 8). The small airstream breaks up the column of blood as it passes the air inlet, increasing the air-to-material ratio in the line and allowing a much greater pickup height. Because the proper amount of air must be determined by trial and error, the air inlet should be provided with a variable control valve. The height of pickup can be increased as the amount of air is increased, so long as there is a vacuum within the pipe sufficient to lift the blood column up past the air inlet.

The receiving tank designed for system A holds blood for a given period, such as for a batch-cooking process. However, in this experimental setup, the blood was blown onto the feathers in the offal

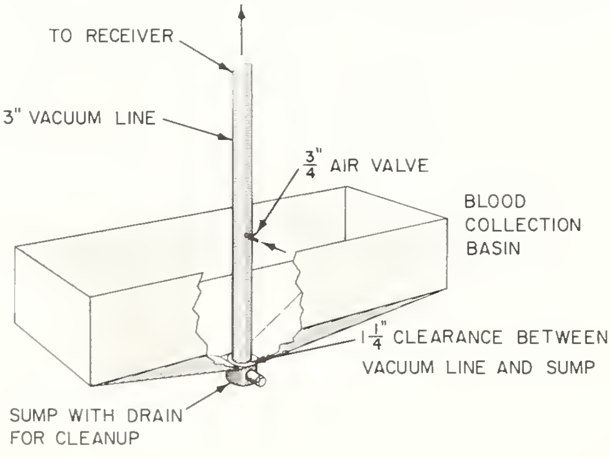

FIGURE 8.—Details of the blood-collection basin where blood is lifted upward through the vacuum line.

TABLE 1.—*Characteristics of total effluent from a poultry processing and rendering plant before and after installation of blood and lung handling system B*

Parameter	Before[1] (mg/l)	After[2] (mg/l)	Percent reduction
Biochemical oxygen demand (BOD_5)	916	509	44
Chemical oxygen demand (COD)	1,543	838	46
Fat	195	145	26
Suspended solids	331	250	24

[1]Values are the averages of 6 determinations taken at weekly intervals. Blood and lungs were discharged into water.

[2]Values are the averages of 5 determinations taken at weekly intervals.

truck. The tank could have been located over the offal truck where discharge could be accomplished by gravity, as in system B. System B is suitable for transferring blood to a continuous rendering operation or a transport truck. The contents are released between pickup cycles and can be throttled by a valve to control the rate of discharge.

The waste effluents from a processing plant with a blood and lung handling system similar to system B were analyzed. The wastewaters were sampled weekly for 6 weeks prior to and for 5 weeks after the installation of the blood and lung handling equipment. Analyses of BOD_5, COD (chemical oxygen demand), fat, and suspended solids were performed according to current water-pollution control standards.[7] Total water use, determined by meters, averaged about 16 gal/bird for processing, cleanup, and onsite rendering, both before and after the installation of the blood and lung system. The blood and lung handling system significantly reduced the plant's waste discharge (table 1).

Experimental results with the two systems described in this report demonstrate that blood can be collected and removed in a manner that greatly reduces pollution. Such systems also reduce labor costs for slaughter area cleanup by one-half and provide much better working conditions.

In most processing plants, a pneumatic blood-collection system does not have to be elaborate,

[7]American Public Health Association. 1971. Standard methods for the examination of water and wastewater. 13th ed., 874 pp. The Association, New York.

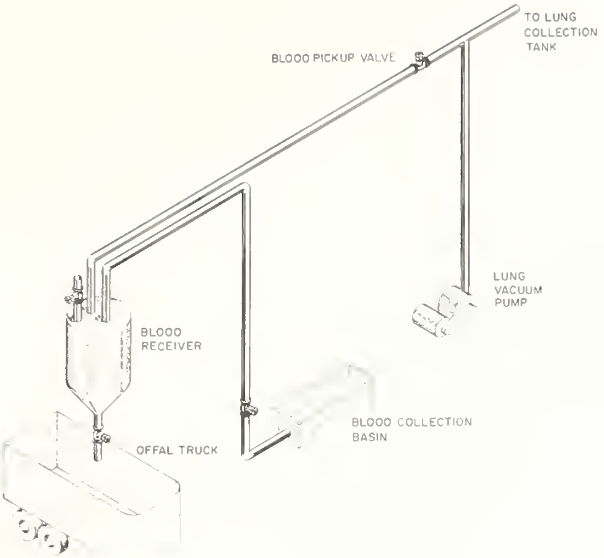

FIGURE 9.—A simple design for a blood-collection system to be operated from a lung-removal vacuum system.

complicated, or expensive. Nor does it have to be automated. Figure 9 shows how collection and receiving components can be tied into the existing plant lung system so that the lung-removal vacuum pump can be used to pick up the blood during an employee break period. The pickup can be accomplished by manually opening one valve and would require less than 5 minutes. Controls could provide a system in which the pickup cycle could be accomplished by pushing one button that would open the blood pickup valve and close it after a predetermined interval, usually 1 to 2 minutes. Management must decide how much the system should be automated for maximum benefit.

APPENDIX.—OPERATION OF SYSTEMS

System A

Controls and wiring diagram

The primary components of the control system are two timer clocks, one stepper switch, and nine relay switches (fig. A-1). Clock 1 has three rotary switches (C1-1, -2, -3), and clock 2 has six (C2-1, -2, . . ., -6). The stepper switch has three tiers of contacts and is powered by a 24V-d.c. stepdown transformer with a solid-state rectifier. Each tier has five contacts and the wiper arms move from one contact to the next on each tier simultaneously.

Clock 1 is used to trigger the pickup and discharge cycles at predetermined intervals. Switches C1-1 and C1-2 trigger the blood-pickup cycles on collection basins 1 and 2, respectively, at 1-hour intervals, and switch C1-3 triggers the discharge cycle at 2-hour intervals (fig. A-1).

Blood-pickup cycle

Between pickup cycles, the switches on the stepper-switch tiers are in position 1, where the blood-pickup cycle can be activated manually by switch S-1. Such manual switching is essential for cleanup crews and maintenance purposes.

At the end of the first hour, clock 1 activates the pickup cycle by means of a 5-second time-delay relay, R-7, and relay R-8, which controls the pickup operation. The signal passing to the stepper switch advances the stepper to position 2, where tier 1 is connected to the normally open side of relay R-9, tier 2 deenergizes the manual switches (S-2, -3, -4) and energizes the vacuum pump, and tier 3 is blank. When the vacuum builds to 7 inHg in the receiver tank, the vacuum switch, S-9, closes, energizing relay R-9, which advances the stepper to position 3. In position 3, tier 1 is connected to the normally closed side of relay R-9, which is now held open, tier 2 continues to operate the vacuum pump, and tier 3 energizes the solenoid, D, to pick up valve A

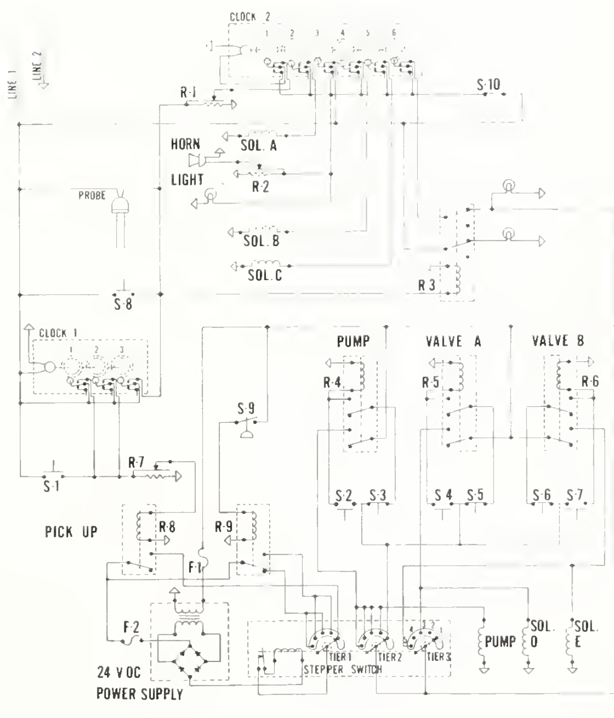

FIGURE A-1.—Schematic wiring diagram for system A.

on blood-collection basin 1. Free air begins to pass through the line as all blood is evacuated from basin 1, causing the vacuum pressure to drop. When the pressure drops to 5 inHg, vacuum switch S-9 opens, deenergizing relay R-9, which advances the stepper to position 4.

In position 4, tier 2 continues to run the pump, and tier 3 closes valve A to basin 1. As the pickup valve to basin 1 closes, the vacuum begins to build within the system again. Vacuum switch S-9 again energizes relay R-9, advancing the stepper to position 5. Tier 3 energizes the solenoid to pickup valve B on basin 2, while tier 2 continues to run the vacuum pump. Vacuum pressure again drops in the system after blood is evacuated from basin 2. At 5 inHg, vacuum switch S-9 deenergizes relay R-9, returning the switch to the starting position. Tier 2 turns off the pump and reactivates manual operation, and tier 3 deactivates the solenoid to basin 2, completing one blood-pickup cycle.

As noted earlier, the system can be operated by manual push button. Switch S-2 starts the pump, and S-2 and S-4 open the pickup valves to basins 1 and 2, respectively. Switch S-1 activates the automatic blood-pickup cycle. After the second pickup cycle (at the end of the second hour) the blood-discharge cycle is activated.

Blood-discharge cycle

The discharge cycle is triggered at the end of each 2 hours by clock 1 by means of a 20-second time-delay relay, R-1, which activates clock 2. Clock 2 can also be triggered by the overfill probe or by a manual switch, S-8, through relay R-1. The current comes to the normally closed side of switch C2-1 and moves the clock forward until switch C2-1 is activated. At this point, power to the clock is transferred to the normally open side of switch C2-1, and power for the remainder of the cycle is supplied through a switch, S-10, in the offal room. This switch allows the person in charge of the offal room to stop the cycle if blood discharge has to be delayed.

At 5 seconds into the discharge cycle, switch C2-6 cuts all power to the pickup operation, and switch C2-3 activates a flashing light and a siren in the offal room. After sounding for 5 seconds, the siren is turned off by delay relay R-2. The warning light continues to flash throughout the discharge cycle and is not even interrupted by turning off the offal-room switch. The first 75 seconds of the discharge cycle is a warning period, allowing the offal-room operator time to throw the switch to halt the cycle if the equipment is not in place. At 75 seconds into the period, switch C2-5 energizes air solenoid A, which closes all valves to isolate the collection tank and opens discharge valve E (fig. 2). At 85 seconds, switch C2-4 energizes the tank air solenoid, B, pressurizing the tank. At 180 seconds, switch C2-2 energizes water solenoid C to the tank CIP system. At 220 seconds, the air is shut off by switch C2-4, the water by switch C2-5, and the tank valves return to their normal position, discharge valve E closes, and valve D to the vacuum pump opens. At 240 seconds, switch C2-6 ends the discharge cycle and returns the system to pickup operation. Switch C2-3 turns off the warning light, and clock 2 shuts itself off by switch C2-1.

If the tank fails to discharge and comes close to being filled, the probe (fig. 3) energizes relays R-1 and R-3, triggering the discharge operation. If the tank still fails to discharge, relays R-1 and R-3 remain energized. Relay R-1 cuts the clock-triggering signal after 20 seconds, preventing continuous cycling. Relay R-3 prevents a manual operation from resuming pickup and keeps a red panel light burning as long as the probe keeps it energized, until the malfunction is corrected and the tank is emptied.

System B

Controls and wiring diagram

In system B, the timing of cycles and the sequencing of events is done by two clocks (fig. A-2). Clock 1 activates each cycle at predetermined intervals (7.5 min were used in this experiment, but settings are possible at 15-, 30-, or 60-min intervals). Clock 2 has six switches (C2-1, -2, ..., -6) that are employed to sequence and activate all intermediate activities throughout the cycle, which requires a total of 2 min. The only function of switch C2-1 is to turn the clock motor one revolution each time the switch is activated (which corresponds to the 1-system cycle).

Warning system

A warning system was incorporated into the mechanical and electrical controls so that malfunctions could be quickly located and corrected. The fail-safe aspects of the system normalize the controls in case of the temporary interruption of air or electrical services on certain circuits. All valves must function properly for the system

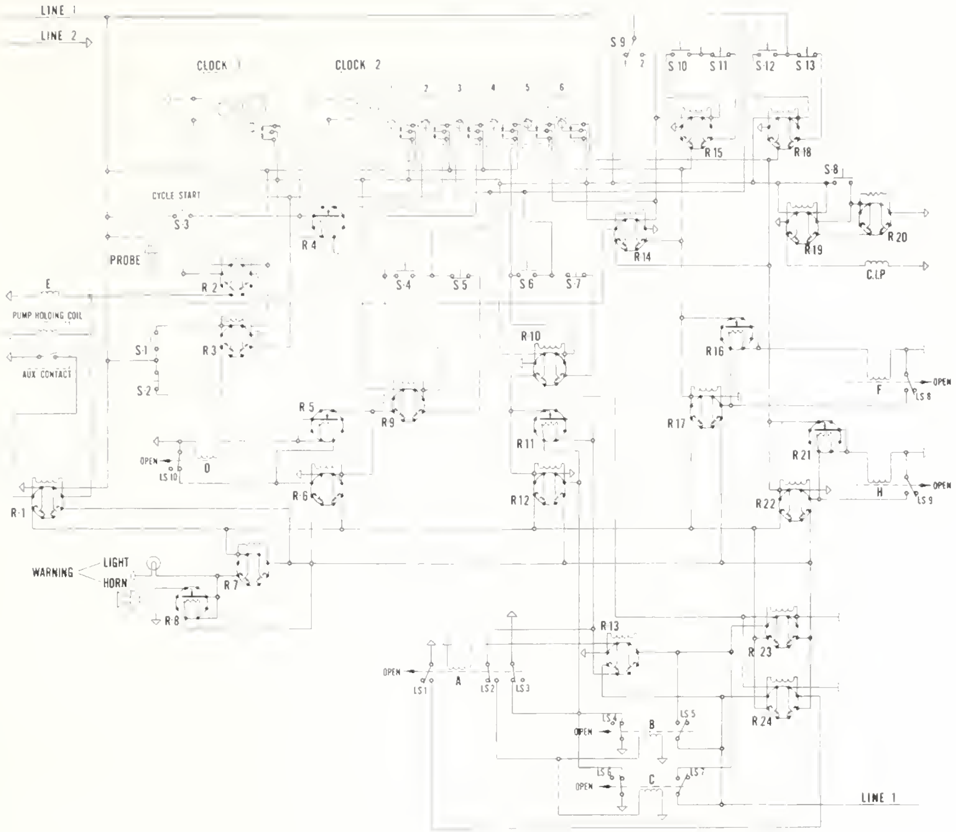

FIGURE A-2.—Schematic wiring diagram for system B.

to perform effectively. Since they are opened and closed by air cylinders, it is always possible for a valve to stick.

The warning system is connected to limit switches located at either the open, closed, or both ends of the cylinder stroke that operates the valves, depending on the function of each valve (fig. A-3). If a valve malfunctions, the warning system is activated after a 10-second delay.

The warning system consists of a revolving red light and a siren. When activated, the siren sounds for 15 seconds, and the revolving light continues until the malfunction is corrected. A malfunction at the pump or any valve can activate the warning system, and if there is more than one valve malfunctioning it will continue until all are corrected. The warning system also activates a light and a bell at maintenance quarters, indicating which valve has malfunctioned. The warning system may be used on a blood-collection system, dry-waste system and many other areas in a plant.

In addition to triggering the warning system, a valve malfunction also activates relays R-5, R-11, R-16, and R-21. If a valve sticks or jams and does not complete its stroke and contact the appropriate limit switch, the relay for that valve will pulse the circuit, causing the air cylinder to come on and off. This rapid jerking motion, along with the ¾-in slot in the pneumatic cylinder arm (fig. A-3), aids in unsticking the valve. The pulsing circuit also activates the warning light at maintenance quarters.

Blood-pickup cycle

Clock 1 activates clock 2 to begin each cycle (fig. A-2). Switch C2-1 rotates clock 2 through one 2-min cycle. Clock 2 can also be activated by the manual cycle button. The normally closed side of C2-2 supplies current to the manual system. When C2-2 is activated, it shuts off current to the manual system, preventing anyone from activating the valves during the pickup cycle.

The normally open side of C2-2 energizes the holding coil, E, to the vacuum pump (fig. A-2) and the vacuum breaker valve on the receiver (valve E, fig. 6) by means of R-2 or R-3, closing the valve and starting the pump. Current from C2-2 passes through relay R-1. At 10 seconds

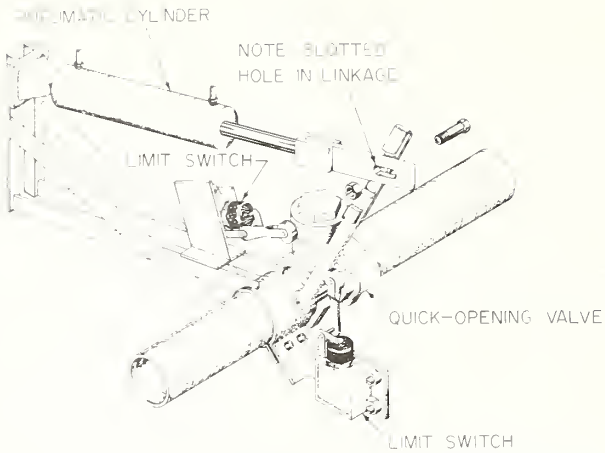

FIGURE A-3.—A quick-opening valve operated by an air cylinder with limit switches for activating the alarm system.

into the cycle, a vacuum has built up in the receiver, and blood-harvest valve D is opened by C2-3, by means of R-9, for the blood pickup. The blood pickup continues for 45 seconds, or to 55 seconds into the cycle, at which time valve D closes, terminating the event.

Lung harvest

Five seconds after valve D closes (at 60 seconds into the cycle), switch C2-4 begins the lung harvest by means of relay R-10. Isolation valve A closes so that lung-removal operations in the eviscerating area will not be interrupted. Vacuum breaker valve B on the lower lung-collection tank opens by means of LS-2, and lung harvest valve C opens for lung pickup, remaining open for 55 seconds. The cycle ends as valves C and B close and valve A opens for normal operations. Also, vacuum breaker valve E and discharge valve F on the lung and blood receiver open, and the vacuum pump shuts off.

To insure that a constant vacuum is maintained in the upper tank (fig. 6), the controls to valves A, B, and C to the lower tank are interlocked. Valves B and C are held closed at all times when valve A connecting the tanks is open. When valves B and C are open, valve A is held closed.

Receiver probe

If the lung and blood receiver comes close to being filled for any reason, the probe, or high-level safety device, energizes relay R-1, which stops the pump and opens the vacuum breaker valve. The other side of relay R-1 shuts off current to the manual operation. The signal from the probe also activates relay R-13, energizing the cooker valve or the sewer valve (depending on the position of the cleanup and process switch) and opening it so that the receiver tank can be emptied. The probe also sounds the warning system by means of isolation relay R-24.